# DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and EN 45014

<table>
<thead>
<tr>
<th>Manufacturer's Name</th>
<th>Bellingham &amp; Stanley Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer's Address</td>
<td>Longfield Road,</td>
</tr>
<tr>
<td></td>
<td>Tunbridge Wells,</td>
</tr>
<tr>
<td></td>
<td>Kent TN2 3EY</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
</tr>
</tbody>
</table>

declares that the product

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Abbe 60 Refractometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Number</td>
<td>All</td>
</tr>
</tbody>
</table>

is designed to conform to the following Product Specifications:

**Safety**
- BS EN 60950-1:2002

**EMC**
- **Emissions**
  - BS EN 61000-6-3:2007 Emission for residential, commercial and light-industrial environments
- **Immunity**
  - BS EN 61000-6-2:2007 Immunity for industrial environments

**Supplementary**
The product herewith is designed to comply with the requirements of the EMC Directive 89/336/EEC.

![CE Mark](image1.png)

This symbol is an internationally agreed indicator that the product bearing it should not be disposed of as general waste or garbage which might end up in landfill sites, but should instead be sent for special processing and/or recycling in those countries where appropriate legislation and facilities are in place.

![Warning Symbol](image2.png)

This symbol indicates a caution or warning, please refer to the manual.
Installing the instrument

Carefully remove all of the packing material. It is recommended that the box and other packing materials are retained so that, should the need arise, the refractometer can be safely returned to the manufacturer. Remove the cable tie that secures the upper prism box during transit. Open the upper prism box and remove packing material from between the two prisms.

Contents list

Abbe Refractometer comprising:
1 Operating Instructions 10-292
1 Instruction manual CD-ROM 55-300
1 Power supply 55-104
1 Bottle of monobromonaphthalene 10-43
1 Calibration test piece see below for part number
1 Mains lead see below for part number
- Calibration Tables see below for part number

Part numbers

Abbe refractometer part numbers

<table>
<thead>
<tr>
<th>Model</th>
<th>Part number</th>
<th>Calibration test piece</th>
<th>Calibration Tables</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 / 95</td>
<td>10-03</td>
<td>Glass, 10-44</td>
<td>Not supplied</td>
</tr>
<tr>
<td>60 / DR</td>
<td>10-99</td>
<td>Glass, 10-44</td>
<td></td>
</tr>
<tr>
<td>60 / ED</td>
<td>10-04</td>
<td>Silica, 10-46</td>
<td>10-295</td>
</tr>
<tr>
<td>60 / LR</td>
<td>10-06</td>
<td>Silica, 10-46</td>
<td>10-297</td>
</tr>
</tbody>
</table>

Power lead part numbers

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains leads (for use with 55-104)</td>
<td>61-191</td>
<td>61-193</td>
<td>61-192</td>
</tr>
</tbody>
</table>
Positioning the system

Place the instrument, and separate light source if used, on a flat and stable bench which is:

- dry and indoors
- away from draughty or hot equipment like fans or heaters
- out of direct sunlight or strong ambient light
- away from potential sources of interference, such as RFI generating equipment
- within reach of a power point
- not using a power circuit that also has large motors or noise generating equipment connected to it

Mains connection

The power supply adapter is supplied with a moulded mains cord and plug, to suit one of several socket types. For UK lead, replace fuse only with the type indicated on plug.

<table>
<thead>
<tr>
<th>Type</th>
<th>Plug Style</th>
<th>Mains cord wire colours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Line (Phase)</td>
</tr>
<tr>
<td>UK (230V)</td>
<td>13 Amp square pin to BS363/A</td>
<td>Brown</td>
</tr>
<tr>
<td>EU (230V)</td>
<td>European Schuko plug 25</td>
<td>Brown</td>
</tr>
<tr>
<td>US (110V)</td>
<td>3 pin American plug</td>
<td>Black</td>
</tr>
</tbody>
</table>

Power requirements

Voltage         110 to 230V $\pm$ 10%, 50 to 60 Hz
Maximum load    less than 50 mA

Power supply adapter

RISK OF ELECTRIC SHOCK:
- For electrical safety information, read the leaflet enclosed with the power supply.
- For indoor use only.
- Must be kept dry.
- Disconnect the equipment from the mains supply before unplugging the mains lead from the power supply unit.
- Do not open the power supply adapter. No user serviceable parts inside.

WARNING:
- For indoor use only.
- Must be kept dry.
- No user serviceable parts inside.
- Do not open.
- Do not cover, designed to operate with free air convection.
- No cleaning required.
Instrument overview

Abbe 60 refractometers can be used to measure the refractive index of liquid or solid samples for a wide range of applications.

There are 2 versions of the instrument:

**Direct Reading models**
- 60/95  Range 1.300 to 1.535
- 60/DR  Range 1.300 to 1.740

Sample values can be read directly from the scale graticule in either refractive index or %sucrose (°Brix).

These models have a built-in adjustable L.E.D. light source at approximately 589nm wavelength.

**High Accuracy models**
- 60/ED  Range 1.30 to 1.74
- 60/LR  Range 1.20 to 1.70

The High Accuracy models have a scale graticule graduated in linear divisions. The sample readings must be converted to refractive index (or other scales such as Brix) using either a software program or conversion tables.

A separate monochromatic light source is required; e.g. a Spectral Lamp Unit with a cadmium, mercury or sodium bulb.
Main parts & controls

- Dispersion drum
  (Direct Reading models)
- Micrometer drum
- Water nozzle
- Upper prism shutter
- Upper prism box
- Integral L.E.D. light source
  (Direct Reading models only)
- Lower prism box
- Water nozzle

- Toggle clamp
- Power switch
  (Fitted to early models only)
- Power connector
- Scale telescope
- Temperature display
- Control knob
- Calibration Adjustment cover
- Desiccator
The upper & lower prism boxes

A liquid sample to be tested is placed on the measurement prism and the upper prism is clamped down onto it forming a thin layer of the sample. Light from the light source passes through upper prism, then is refracted through the sample layer and into the measurement prism.

The upper prism box is held in place by a toggle clamp, which also forces the box up by a few millimetres when opening. The toggle clamp also prevents the upper prism box dropping directly onto the measurement prism and causing damage to the surface.

The upper & lower prism boxes both incorporate water jackets, each with two hose connection nozzles. This enables the sample to be temperature controlled from a water circulator.

The temperature display module

The current temperature of the measurement prism is continually monitored and shown on the display on the rear face of the instrument in degrees Celsius.

Any deterioration of the surface condition of the measurement prism will limit the performance of the instrument and make accurate measurements difficult.
It is important to keep the measurement prism in good condition.
**Direct Reading instruments only**

The Direct Reading instruments have an integral L.E.D. (light emitting diode) light source for sample illumination.

A dispersion drum is fitted to Direct Reading instruments to enable colours other than yellow originating from the L.E.D (or more significantly, an alternative white light source) to be removed from the field view. This will sharpen the borderline and allow accurate setting against the crosswires.

**High Accuracy instruments only**

High Accuracy models are not fitted with an integral L.E.D. light source because a monochromatic light source, such as a sodium lamp, is required to achieve the measurement precision.

A window and shutter are fitted in the lower prism box, which allows the instrument to be alternatively used in reflection, rather than transmission, mode. This is useful when reading dark samples. (See page 3-4 for more details)

- Turn the knob anticlockwise to close the shutter for transmission measurements
- Turn the knob clockwise to open the shutter for reflection measurements
Initial setting up

Power supply

All Abbe 60 refractometers are supplied with an external power supply, which should be plugged into the sealed power connector on the side of the instrument.

The power supply itself is connected to the mains supply by a moulded mains lead, which is also supplied with the instrument.

Connect the mains lead to the mains supply and switch on the supply.

_Early models only, with serial numbers prior to A01051_

Switch the instrument on by pressing down the power switch, located next to the instrument power connector.

Altering the focus of the telescopes

To alter the focus of either of the telescopes, move the lens cap away and towards the main body of the instrument until the scale and the crosswires are well defined. To help the lens cap move, twist it whilst adjusting the focus.

Below are examples of the views that you will get when looking down each of the telescopes (the scale view is that of a Direct Reading instrument).

![Scale view](image)

![Field view](image)

Adjusting the upper prism box shutter

The upper prism box shutter has two separate functions. The first is to control the amount of light from the light source that is passed through the sample; this is necessary to adjust the contrast between the light and dark parts of the borderline.

The other use is to limit unwanted, ambient light entering the prism. If you are using the integral L.E.D. light source on a Direct Reading instrument, it is recommended that the shutter should initially be open about 2mm. This will restrict the amount of white light entering the sample. When using a spectral light source the shutter has a lesser effect, as the light source will be able to flood the sample with light.
Measuring a sample

Setting the borderline

Push the toggle down and raise the upper prism box. Clean the polished surfaces of the upper and measurement prisms using distilled water with a soft tissue. Finish off by drying the prisms with soft tissues.

Apply a few drops of sample to the centre of the measurement prism with a pipette. Lower the upper prism box and lift the toggle clamp to lock it onto the measurement prism. Any excess sample should be wiped away using soft tissues; this will improve the definition of the borderline.

Look into the field telescope and rotate the control knob until the borderline (the point where the light and dark areas meet) comes into view.

It should then be aligned with the centre of the cross hairs in the field telescope.

To obtain the optimal borderline quality, both the light source position and the prism box shutter should be adjusted.

Direct Reading models (Abbe 60/95, 60/DR)
The L.E.D. light source has two adjustable joints, allowing the light to be easily positioned to provide the best borderline. To adjust a joint, turn the associated clamping knob anti-clockwise until it is loose enough to allow the joint to move. Make the adjustment and tighten the knob by turning it clockwise, whilst holding any adjustments in place.

The L.E.D. should be positioned so that it illuminates just the bottom of the upper prism. The dispersion drum control knob should be adjusted to remove as much colour as possible from entering the field view. This will improve the borderline quality. The borderline might need to be re-aligned with the crosshairs after setting the dispersion drum.

High Accuracy models (Abbe 60/ED, 60/LR)
Close the lower prism box window shutter by turning the knob anticlockwise.

Position the external light source directly in front of the Abbe and align the opening in the light source with the upper prism box. Next, adjust the height of the light source, so that all the upper prism box is well illuminated with the light.

If the light source being used requires a filter, this should be slipped over the field telescope lens cap.
Determining the reading value

Direct Reading models (60/95, 60/DR)
Look through the scale telescope and read the measurement value directly from the scale in either refractive index or %sucrose (°Brix).

High Accuracy models (60/ED, 60/LR)
Turn the micrometer drum to the 0 position. Then whilst looking at the scale through the scale telescope, turn the micrometer drum until the previous scale division is straddled centrally by the two fiducial lines.

The example shown would give a value through the scale telescope of 33.3.

Next, read the value on the micrometer drum, this example being 4.3.

The total scale reading will then be:

The value through the scale telescope + the micrometer value divided by 100

Example: $33.3 + \frac{4.3}{100} = 33.3 + 0.043 = 33.343$

Scale reading = 33.343

The operator can then determine the refractive index from the scale reading by one of two methods:

- The Abbe Utilities software
- Calibration table
Using the Abbe Utilities software
Every Abbe refractometer is supplied with an Instruction Manual CD (55-300), contained within this CD is a copy of the Abbe Utilities program, which runs on Microsoft Windows. It provides the ability to convert from Abbe scale reading to refractive index and other scales.

Firstly, check that the Abbe Setup data matches that of your instrument and light source. If the settings are not correct, press and edit the values.

To convert an Abbe scale reading into refractive index, place the cursor in the data entry box below ‘Abbe’, type the Abbe scale value ‘17.243’ and press enter. The equivalent RI, Brix and selected UDS scale values will be shown in the relevant boxes.

Using a Calibration Table
Every High Accuracy instrument is supplied with a calibration table booklet for sodium D line, which will convert Abbe scale readings into refractive index. Below is an example for how the refractive index value for an Abbe scale reading of 17.243 is calculated, using calibration tables.

<table>
<thead>
<tr>
<th>Scale</th>
<th>0.00</th>
<th>...</th>
<th>0.03</th>
<th>0.04</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.1</td>
<td>1.46604</td>
<td>...</td>
<td>632</td>
<td>641</td>
<td>650</td>
</tr>
<tr>
<td>17.2</td>
<td>1.46696</td>
<td>...</td>
<td>724</td>
<td>733</td>
<td>743</td>
</tr>
<tr>
<td>17.3</td>
<td>1.46789</td>
<td>...</td>
<td>816</td>
<td>826</td>
<td>835</td>
</tr>
</tbody>
</table>

First find the correct row in the table, which for the example would be 17.2.

Now find the correct column in that row, e.g. 0.04. The column and row position would give the correct Abbe scale reading for 17.24.

To calculate the refractive index reading, take the RI value for 17.20, which is 1.46696 and substitute the last 3 numbers for the 3 numbers found at 17.24 in the table, 733. This would make the reading 1.46733.

Finally, use the third decimal place of the Abbe scale reading.
Find the refractive index reading for the next column, in this case, 17.25, which would be 1.46743. Then calculate the RI from:

\[ A = \left( \frac{H - C}{10} \right) \times D + C \]

Where:
- \( H \) = Next columns RI value = 1.46743
- \( C \) = First columns RI value = 1.46733
- \( D \) = Scale reading 3rd DP = 3
- \( A \) = Actual RI

\[ A = \left( \frac{1.46743 - 1.46733}{10} \right) \times 3 + 1.46733 = 1.46736 \]

Cleaning the prisms
With the measurement taken, the prism can now be cleaned. Samples should be removed from the prism surfaces as soon as practical after measurement. Leaving sample between the prisms for long periods, and allowing it to dry, can cause the two prisms to stick together.

The sample should be removed from both prisms using a suitable solvent; distilled water or alcohol, depending upon whether the sample is water or oil based, and cleaning with tissue. The prisms should then be finally washed with distilled water or alcohol and dried with clean tissue.

Note:
When cleaning the prisms, please remember that excessive rubbing with abrasive tissues could scratch the prism surfaces. This would reduce the quality of the borderline and also cause sample contamination. B&S do not recommend the use of aggressive solvents such as acetone – always use alcohols or other non-aggressive solvents.

Reflection mode (High Accuracy models only)

If the sample layer is optically dense at the wavelength used, then insufficient light may not pass through it to provide a visible borderline. This problem can generally be overcome by using internal reflection of the light at the interface of the prism and sample.

To use internal reflection
- Slide down the “Upper prism shutter” to prevent light entering into the upper prism.
- Open the “Lower prism box window shutter” by turning the knob clockwise as seen from the front of the instrument.
- Adjust the light source to enter the “Lower prism box window.

The borderline as seen in the field telescope will however be inverted, the darker part of the field being at the top. Usually the contrast is not so good as with transmission mode but in general a sharp line can be obtained.
Calibrating the instrument

The calibration of all Abbe 60 refractometers can be adjusted to accurately set the scale relative to a test piece with known refractive index. This adjustment should only need to be made at infrequent intervals, but it is recommended that the test piece be applied as a daily routine to check that all is in order and the instrument is reading correctly. Certainly check at each change of user since the setting position varies from one person to another.

Checking the instrument with the test piece

Apply two small drops of monobromonaphthalene contact liquid (supplied with the instrument, code no. 10-43) to the centre of the measurement prism, using a small wooden or plastic stick. The test piece should be placed polished side down onto the prism on top of the contact liquid. Take care when applying the test piece not to scratch the prism. The contact liquid should spread out under the test piece and cover the whole of the interface between the test piece and the prism.

It is important to use the correct amount of contact liquid; there should be just sufficient to cover the interface but should not spread beyond the test pieces edges. The correct amount can only be found with experience.

To check the test piece is applied correctly, see that it does not rock. If it does, remove the test piece and clean off the contact liquid; then re-apply as above.

To remove a test piece from the prism, apply an alcohol-based solvent liberally around the test piece and allow it to “float” off the prism surface with the minimum of sliding.

Each test piece is identified by a serial number and is supplied with a Certificate of Precision specifying its actual refractive index.

For Direct Reading models, the refractive index can be read from the scale and compared with the test piece value.

For High Accuracy instruments, the correct Abbe scale reading for the silica test piece can be found on the front page of the Calibration Table supplied with the instrument. If the Abbe Utility software is used, press Reference and the correct Abbe scale reading will be displayed.
Adjusting the instrument calibration

Ensure that the borderline is accurately aligned with the cross wires in the field telescope. Unscrew and remove the Calibration Adjustment Cover.

Direct Reading models (Abbe 60/95, 60/DR)
Gently adjust the calibration screw using a large flat screw driver so that the correct reading is shown in the scale telescope.

High Accuracy models (Abbe 60/ED, 60/LR)
Set the micrometer drum to the last 2 decimal places of the scale reading for the test piece, when displayed to 3 decimal places. For example, if the scale reading should read 16.275 then the micrometer drum should be set to 7.5. If the scale reading should be 16.002 then the micrometer drum should be set to 0.2.

Gently adjust the calibration screw using a large flat screw driver so that the correct value is in the middle of the two fiducial lines. If the scale reading should be 16.275, then the scale should read 16.2, e.g. the scale marker for 16.2 should be straddled by the fiducial lines.

All models
Finally, always replace the Calibration Adjustment Cover
Temperature effects on the measurement

Temperature correction of the refractometer
If the instrument is used to take measurements at any temperature other than 20°C, then it will be necessary to apply a temperature correction to the scale reading. This is to compensate for the change of refractive index of the prism at the working temperature; the instrument being initially calibrated at 20°C.

Direct Reading models

Abbe 60/95

<table>
<thead>
<tr>
<th>Measured Brix value</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction: °Brix/°C</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.004</td>
<td>0.004</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measured Refractive index</th>
<th>1.30 to 1.535</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction: Refractive Index/°C</td>
<td>0.000076</td>
</tr>
</tbody>
</table>

Abbe 60/DR

<table>
<thead>
<tr>
<th>Measured Brix value</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction: °Brix/°C</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.004</td>
<td>0.004</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measured Refractive index</th>
<th>1.30 to 1.74</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction: Refractive Index/°C</td>
<td>0.000078</td>
</tr>
</tbody>
</table>

Examples:

A 60/95 gives a reading of 35.4 °Brix at a temperature of 75 °C

\[
(T - 20) \times 0.004 = 55 \times 0.004 = 0.22
\]

Scale reading of instrument = 35.4
Corrected reading = 35.62

A 60/DR gives a reading of 1.4864 at a temperature of 70 °C

\[
(T - 20) \times 0.0000078 = 50 \times 0.0000078 = 0.00039
\]

Scale reading of instrument = 1.4864
Corrected reading = 1.48679

High Accuracy models (Abbe 60/ED, 60/LR)

Using the Abbe Utilities software
Enter the measurement temperature in Abbe Setup and the correction will be carried out automatically.

Using a Calibration Table
Details for correction with temperature are shown at the end of the tables.
Temperature correction of the sample

The refractive index of all samples will vary with temperature. If it is required to know the refractive index of the sample at 20°C, then either the instrument must be controlled at 20°C, as described below, or a correction value for the sample must be added to the scale reading.

The correction value will vary considerably with the type of sample. Glass samples have a low temperature coefficient, water based products are higher and oils and chemicals generally greatest. Typical (and very approximate) values are:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Temperature coefficient: Change in index / °Celsius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>+0.00001</td>
</tr>
<tr>
<td>Water</td>
<td>-0.00010 (-0.07°Brix)</td>
</tr>
<tr>
<td>50% sucrose sample (50°Brix)</td>
<td>-0.00017 (-0.08°Brix)</td>
</tr>
<tr>
<td>Edible oil</td>
<td>-0.00040</td>
</tr>
</tbody>
</table>

Correction values for sucrose solutions measured on the Brix (% Sucrose) scale are shown in the table below. The correction values should be added to the scale reading.
<table>
<thead>
<tr>
<th>Temperature °Celsius</th>
<th>°Brix</th>
<th>°Brix</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>-0.29</td>
<td>-0.32</td>
</tr>
<tr>
<td>16</td>
<td>-0.24</td>
<td>-0.26</td>
</tr>
<tr>
<td>17</td>
<td>-0.18</td>
<td>-0.20</td>
</tr>
<tr>
<td>18</td>
<td>-0.12</td>
<td>-0.14</td>
</tr>
<tr>
<td>19</td>
<td>-0.06</td>
<td>-0.07</td>
</tr>
<tr>
<td>20</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>21</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>22</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>23</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>24</td>
<td>0.27</td>
<td>0.28</td>
</tr>
<tr>
<td>25</td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td>26</td>
<td>0.42</td>
<td>0.43</td>
</tr>
<tr>
<td>27</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>28</td>
<td>0.58</td>
<td>0.60</td>
</tr>
<tr>
<td>29</td>
<td>0.66</td>
<td>0.67</td>
</tr>
<tr>
<td>30</td>
<td>0.74</td>
<td>0.76</td>
</tr>
<tr>
<td>31</td>
<td>0.83</td>
<td>0.84</td>
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<tr>
<td>32</td>
<td>0.92</td>
<td>0.93</td>
</tr>
<tr>
<td>33</td>
<td>1.01</td>
<td>1.02</td>
</tr>
<tr>
<td>34</td>
<td>1.10</td>
<td>1.11</td>
</tr>
<tr>
<td>35</td>
<td>1.19</td>
<td>1.21</td>
</tr>
<tr>
<td>36</td>
<td>1.29</td>
<td>1.30</td>
</tr>
<tr>
<td>37</td>
<td>1.39</td>
<td>1.40</td>
</tr>
<tr>
<td>38</td>
<td>1.49</td>
<td>1.50</td>
</tr>
<tr>
<td>39</td>
<td>1.59</td>
<td>1.60</td>
</tr>
<tr>
<td>40</td>
<td>1.69</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Example: A 60/95 gives a reading of 35.4 °Brix at a temperature of 32 °C
Scale reading of instrument = 35.4
Correction = 0.99
Equivalent value at 20 °C = 36.39
Temperature control from a circulator

Both the fixed and hinged prism boxes are fitted with nozzles for water circulation in order to maintain the prisms and sample at known temperatures.

By controlling the instrument to a constant temperature, the time necessary for the instrument to stabilise after applying a sample to the prism will be minimised and measurement conditions will be optimised for high accuracy work.

If it is practical to control the instrument temperature to 20°C, the corrections for the instrument and the sample detailed above will not be required.

It is recommended that the two boxes are connected in series as follows.

Incoming water should be fed into the left hand side of the main body, when viewed from behind. The water will exit through the right side of the main body. A 45cm long pipe should be connected to this nozzle and connected to the right hand nozzle of the upper prism box. A pipe on the left nozzle on the upper prism box will return the water back to the circulator. With the instrument set-up as above, the Abbe will have both the water connections to the water bath on the left hand side, when viewed from behind. It is advisable to secure the pipes to the nozzles with hose clips. (The photograph shows the pipes without clips for clarity).
Measurement techniques

Sample application

Liquid samples
It is recommended that liquid samples be transferred to the prism surface using a pipette rather than a stirring rod or pouring directly from a beaker. After taking up the sample, any drips adhering to the outside of the pipette should be wiped off then discharge a few drops from the pipette directly onto the prism surface and close the prism box. This is of considerable importance when taking concentration measurements since thin films adhering to a stirring rod and exposed to the atmosphere can evaporate solvent rapidly when moved through the air, giving rise to errors in measurement.

Solid Samples
These are applied in the same manner as the test piece using a contact liquid. A surface must be prepared, polished as flat as possible and placed on the prism surface with the hinged prism opened out of the way. If the solid has an index higher than 1.65, methylene iodide can be used as a contact liquid (B&S code 10-61) in place of monobromonaphthalene which can only be used up to this limit.

Thin Films
Results may be obtained on most thin films but here a technique must be evolved, determined by the material and conditions.

Direct Application (Reflection mode: High Accuracy models only)
Soft plastics and rubbery materials may be cured in a press between thin sheets of aluminium foil and reduced to a thickness of about 0.25mm. After preparation ensure that the prism surface is clean, strip off the foil on one side of the film and apply the exposed surface directly to the prism using no contact liquid.

Indirect Application (Reflection mode: High Accuracy models only)
Resins and other low melting point solids are best prepared by melting them onto a thin glass substrate (B&S code 10-59). After hardening, the substrate should be placed on the prism surface with a contact liquid with the coated surface uppermost. Two borderlines will appear, one due to the sample, the other due to the substrate which may be previously found and ignored. It is essential that the refractive index of the substrate should be greater than that of the sample.

Dark samples (Reflection mode: High Accuracy models only)
With certain materials of a non-transparent nature, such as thick oils, tar, marzipan etc., too much light may be absorbed in the sample film or be so scattered that definition is lost. In these cases, the trouble can generally be overcome by using reflection mode.
**Accessories**

**Volatile Liquid Cell**

This comprises a rectangular glass block, with one side hollowed out to form a cavity. Two holes pass between the cavity and the opposite face of the block.

To use the cell, first ensure that the prism surface and the cavity face of the block are clean.

Place the block, cavity down on the prism surface, and by means of a syringe, introduce sample into the cavity via the end filling port, leaving the central port clear for the escape of air. Fill the cavity and the filling ports to the top face of the block. After removing the syringe, close the filling ports by laying the thin plate over the top surface. The sample is now completely isolated from the atmosphere and will not be subject to evaporation.

The cell capacity is in the region of 0.3 ml and this may be saved after measurement by drawing back into the syringe or lost by lifting the cell from the prism face for cleaning and drying.

**Divided Cell for differential measurements**

This is a circular cell with a dividing partition providing two sample compartments of semicircular form.

Before use, it is necessary to clean the prism surface and the base disc of the cell. Place a small drop of contact liquid in the centre of the prism surface, then place the cell in position on top of the prism with the partition parallel to the sides of the prism and central.

Sample and reference are placed in the separate compartments and the control knob turned to bring the borderlines into view. The borderline due to each half of the cell occupies about two thirds of the field, thus extending sufficiently across the cross line for a setting to be made. The two may be compared accurately one against the other and, since they are in the same cell, under identical conditions, there is little risk of error due to temperature. It should be noted that, when observed in the field of view, the borderline to the left side arises from the sample on the right side of the partition and vice versa. This is due to the optical system within the instrument causing a reversal.
Funnel Flowcell

Attaching the flowcell to the prism box.

- Remove the two hexagon headed bolts securing the prism box hinge to the lower prism box and completely remove the upper prism box.
- Remove the two countersunk screws from either side of the toggle fastener and detach fastener.
- Fit two angle brackets provided with the flow-cell to either side of the prism plate using the screws provided with the flowcell.
- Check that the silicon rubber gasket is fitted in the flowcell with the rectangular aperture allowing unrestricted flow through the two inlet and outlet holes.
- Fit the flowcell to the brackets, tightening the two knurled screws together to ensure that the flowcell sits parallel to the prism plate and the seal is uniformly compressed.

Filling the flowcell

The cell is provided with a filling funnel and a drain tube with antisyphon tube. This prevents the cell being drained by syphonic action in use. Place an empty beaker below the drain tube and pour in about 50 ml of distilled water into the funnel. Check for any leaks around the base of the flow cell. If any appear, check the tightening of the clamp screws and, if necessary, remove the cell and reseat.

The light source must be critically adjusted for the flow cell since the aperture is restricted and it is essential that the source is in the correct position. There is a recessed window for the admission of illumination between the two water jacket nipples. The light source must be adjusted to the same height as this aperture.

The control knob is now used to set the scale to the correct reading for water, taking the temperature into account (1.3330 at 20°C). The borderline will appear as an illuminated band across the crosswires. It is the lower edge of the band that is of importance. (Direct Reading models only: any colour at the edges of the band should be cleared by rotating the dispersion control.) The upper edge of the illuminated band is formed by a cut off by the cell entrance aperture and is thus out of focus and may be diffused. The lower edge, however, should be sharply defined and free from colour and is to be used in all measurements.

It is possible that the lower (borderline) edge is not in coincidence with the crosswire intersection, this being due to a physical displacement of the prism plate caused by the pressure of the flow cell. This is of no consequence and only requires an adjustment to the zero as detailed in Section 3.

Care must be taken in the use of the flow cell to avoid air pockets becoming trapped in the chamber. If this occurs, impairing definition, the instrument should be slightly inclined to attract the
bubble towards the rear end and flushed out with the addition of more sample.

The number of flushes of the chamber between samples will depend upon the nature of the sample, and the difference in index between successive samples. It will be quickly established how much sample is required. For a start, the chamber should be flushed a number of times using about 15 ml each time. A reading should be taken between each flushing. When no change occurs between two such readings, it is an indication that flushing is adequate. Obviously, the greater the difference in refractive index between two samples, the greater the quantity required for flushing.

Using filters

Two types of filter are available, a Polarising Filter and a Spectral Line Filter. Both are mounted in a cap which fits over the field telescope.

Polarising (Bi-Refringent) filter
A polarising filter can be used on both the Direct Reading and High Accuracy models for the examination of bi-refringent materials. Rotation of the cap on top of the field telescope eyepiece will bring each borderline into prominence in turn and is a useful accessory particularly if the separation makes accurate settings difficult.

Spectral filters
Bellingham + Stanley can also supply filters which will pass a specific wavelength of light. These can be used on the High Accuracy models to isolate readings with specific wavelengths from, typically, a mercury or cadmium lamp.
## Spares and accessories

### Power supplies

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-104</td>
<td>Power supply 110 to 230V ±10% 50 to 60Hz</td>
</tr>
<tr>
<td>61-191</td>
<td>UK mains lead (for use with 55-104)</td>
</tr>
<tr>
<td>61-193</td>
<td>Euro mains lead (for use with 55-104)</td>
</tr>
<tr>
<td>61-192</td>
<td>US mains lead (for use with 55-104)</td>
</tr>
</tbody>
</table>

### Cells

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-41</td>
<td>Stainless steel funnel flow cell for repetitive sampling</td>
</tr>
<tr>
<td>10-80</td>
<td>Silicon rubber flow cell gasket</td>
</tr>
<tr>
<td>10-42</td>
<td>Volatile liquid cell</td>
</tr>
<tr>
<td>10-58</td>
<td>Divided cell for differential measurements</td>
</tr>
<tr>
<td>10-59</td>
<td>Glass substrate for resin samples</td>
</tr>
</tbody>
</table>

### Contact liquid

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-43</td>
<td>Contact liquid (monobromonaphthalene) for test plates and solid samples with RI up to 1.65. Quantity 6 ml.</td>
</tr>
<tr>
<td>10-61</td>
<td>Contact liquid (methylene iodide) for test plates and solid samples with RI up to 1.74. Quantity 3 ml.</td>
</tr>
</tbody>
</table>

### Eye piece filters

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>10-69</td>
<td>Spectral filter eyecap (manufactured to order)</td>
</tr>
<tr>
<td>10-49</td>
<td>Polarising eyecap for bi-refringent samples</td>
</tr>
</tbody>
</table>

### Test pieces

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-44</td>
<td>Glass test plate with RI approximately 1.5222</td>
</tr>
<tr>
<td>10-46</td>
<td>Silica test plate RI 1.45839 (traceable)</td>
</tr>
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</table>
### External light sources

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>59-01</td>
<td>Free standing sodium lamp outfit 190/250v AC, 50/60 Hz</td>
</tr>
<tr>
<td>59-06</td>
<td>Free standing sodium lamp outfit 100/130v AC, 50/60 Hz</td>
</tr>
<tr>
<td>59-50</td>
<td>Spare sodium bulb (for use with 59-01 and 59-06)</td>
</tr>
<tr>
<td>59-20</td>
<td>Free standing spectral lamp outfit 190/250v AC, 50/60 Hz</td>
</tr>
<tr>
<td>59-25</td>
<td>Free standing spectral lamp outfit 100/130v AC, 50/60 Hz</td>
</tr>
<tr>
<td>59-37</td>
<td>Cadmium lamp (for use with 59-20 and 59-25)</td>
</tr>
<tr>
<td>59-33</td>
<td>Mercury lamp (for use with 59-20 and 59-25)</td>
</tr>
<tr>
<td>59-31</td>
<td>Sodium lamp (for use with 59-20 and 59-25)</td>
</tr>
<tr>
<td>59-39</td>
<td>Helium lamp (for use with 59-20 and 59-25)</td>
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</table>

### Miscellaneous

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>55-300</td>
<td>Instruction Manual CD containing Abbe Utilities software</td>
</tr>
<tr>
<td>10-292</td>
<td>Instruction manual (English)</td>
</tr>
<tr>
<td>10-293</td>
<td>Instruction manual (Spanish)</td>
</tr>
<tr>
<td>10-294</td>
<td>Instruction manual (French)</td>
</tr>
<tr>
<td>10-299</td>
<td>Instruction manual (German)</td>
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